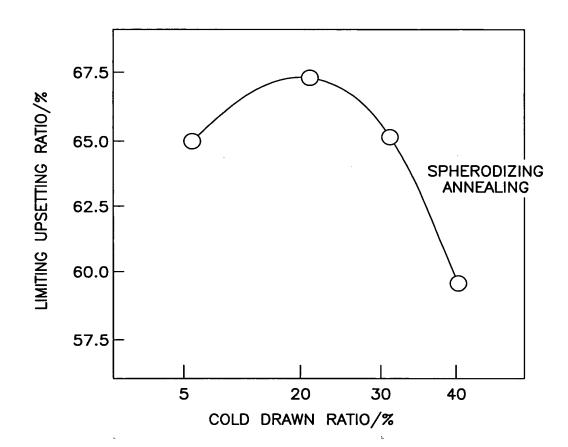
Inventor: Ando, et al.
Docket No.: 12052.0033USD2
Title: BILLET FOR COLD FORGING, METHOD OF MANUFACTURING BILLET FOR
COLD FORGING, METHOD OF CONTINUOUSLY COLD-FORGING BILLET, METHOD OF COLD-FORGING Serial No.: 10/789,347 Sheet 1 of 39 p Ø | → → | DRAWING CROSS SECTIONAL =20% 0 Ø ---BONDERINZING SHOT BLASTING ACID PICKLING BONDERIZING 20° C/hr 680° C COOLED IN FURNACE COOLED IN FURNACE SPHERODIZING ANNEALING (2ND) ວູ089-SPHERODIZING ANNEALING ਲੁੱ 750°C X 2hr 740°C X ACID PICKLING ACID PICKLING CUTTING BAR

Inventor: Ando, et al.
Docket No.: 12052.0033USD2
Title: BILLET FOR COLD FORGING, METHOD OF MANUFACTURING BILLET FOR
COLD FORGING, METHOD OF CONTINUOUSLY COLD-FORGING BILLET, METHOD
OF COLD-FORGING
Serial No.: 10/789,347
Sheet 2 of 39

FIG.2



Inventor: Ando, et al.

Docket No.: 12052.0033USD2

Title: BILLET FOR COLD FORGING, METHOD OF MANUFACTURING BILLET FOR COLD FORGING, METHOD OF CONTINUOUSLY COLD-FORGING BILLET, METHOD OF COLD-FORGING

Serial No.: 10/789,347

Sheet 3 of 39

FIG. 3A

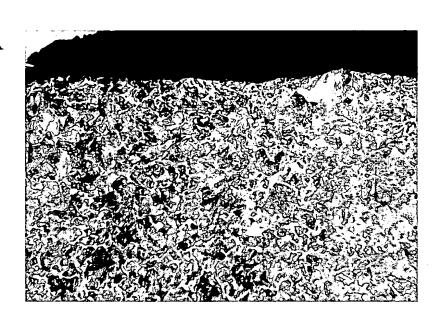
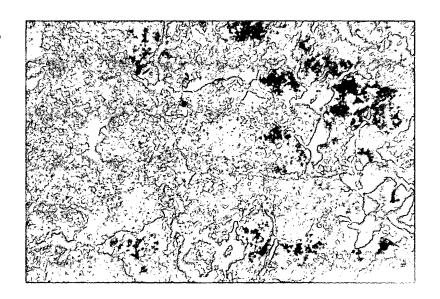


FIG. 3B



Inventor: Ando, et al.
Docket No.: 12052.0033USD2
Title: BILLET FOR COLD FORGING, METHOD OF MANUFACTURING BILLET FOR
COLD FORGING, METHOD OF CONTINUOUSLY COLD-FORGING BILLET, METHOD
OF COLD-FORGING
Serial No.: 10/789,347
Sheet 4 of 39

FIG. 4A

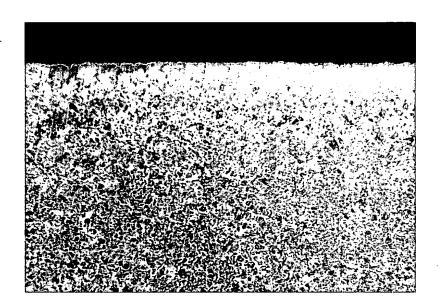
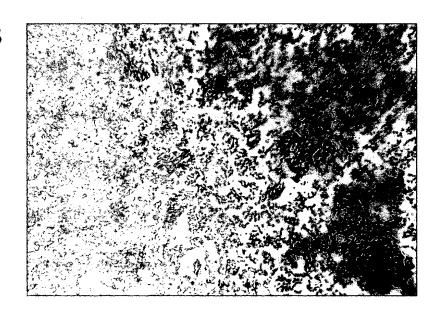


FIG. 4B



Inventor: Ando, et al.
Docket No.: 12052.0033USD2
Title: BILLET FOR COLD FORGING, METHOD OF MANUFACTURING BILLET FOR
COLD FORGING, METHOD OF CONTINUOUSLY COLD-FORGING BILLET, METHOD
OF COLD-FORGING
Serial No.: 10/789,347
Sheet 5 of 39

FIG. 5A

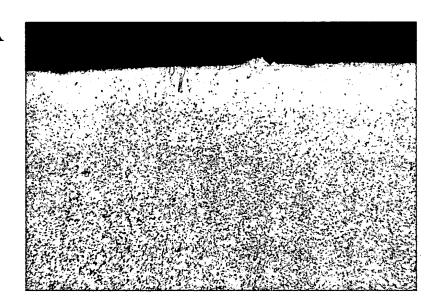
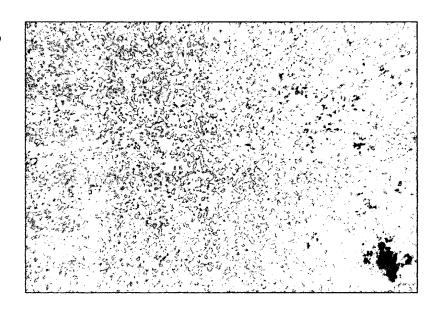


FIG. 5B



Inventor: Ando, et al.
Docket No.: 12052.0033USD2
Title: BILLET FOR COLD FORGING, METHOD OF MANUFACTURING BILLET FOR COLD FORGING, METHOD OF CONTINUOUSLY COLD-FORGING BILLET, METHOD OF COLD-FORGING

Serial No.: 10/789,347 Sheet 6 of 39

FIG. 6A

MATERIAL 1 ASPECT RATIO = 506%

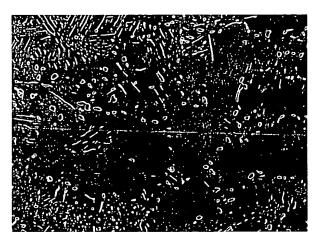


FIG. 6B

MATERIAL 2 ASPECT RATIO = 347%

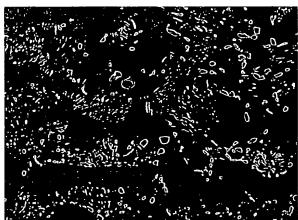
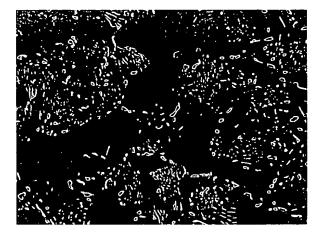


FIG. 6C

MATERIAL 3 ASPECT RATIO = 300%



Inventor: Ando, et al. Docket No.: 12052.0033USD2

OF COLD-FORGING Serial No.: 10/789,347 Sheet 7 of 39

Title: BILLET FOR COLD FORGING, METHOD OF MANUFACTURING BILLET FOR COLD FORGING, METHOD OF CONTINUOUSLY COLD-FORGING BILLET, METHOD

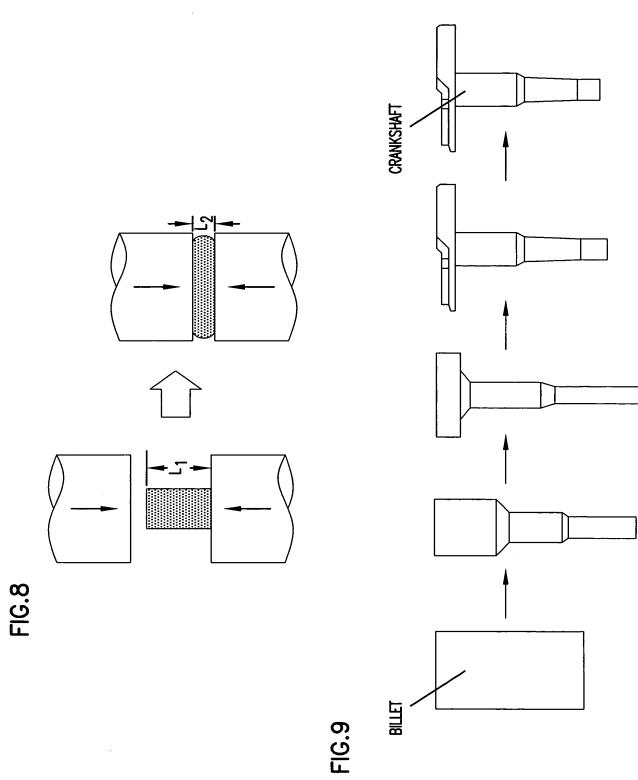
Inventor: Ando, et al.

Docket No.: 12052.0033USD2

Title: BILLET FOR COLD FORGING, METHOD OF MANUFACTURING BILLET FOR COLD FORGING, METHOD OF CONTINUOUSLY COLD-FORGING BILLET, METHOD OF COLD-FORGING

Serial No.: 10/789,347

Sheet 8 of 39



Inventor: Ando, et al.
Docket No.: 12052.0033USD2
Title: BILLET FOR COLD FORGING, METHOD OF MANUFACTURING BILLET FOR
COLD FORGING, METHOD OF CONTINUOUSLY COLD-FORGING BILLET, METHOD OF COLD-FORGING Serial No.: 10/789,347 Sheet 9 of 39 SPHERODIZING ANNEALING ACID PICKLING CUTTING ACID PICKLING SURFACE—HARDENED MATERIAL 6: COOLING BED 7: ROD 8: COIL MATERIAL 7: ROD WINDER 4: CUTTING SHEAR 5: COOLING DEVICE 3: ROLLING MACHINE 2: BLANK

FIG. 10

HEATING FURNACE

Inventor: Ando, et al. Inventor: Ando, et al.
Docket No.: 12052.0033USD2
Title: BILLET FOR COLD FORGING, METHOD OF MANUFACTURING BILLET FOR
COLD FORGING, METHOD OF CONTINUOUSLY COLD-FORGING BILLET, METHOD
OF COLD-FORGING
Serial No.: 10/789,347
Sheet 10 of 39

FIG.11A

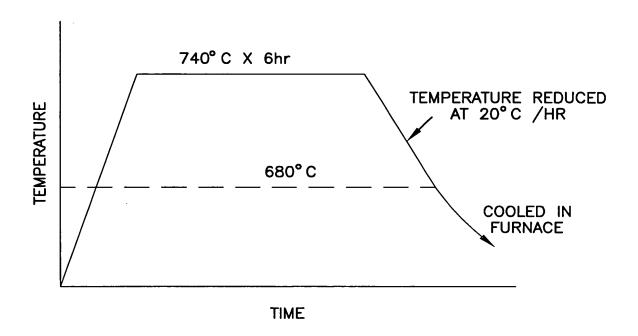
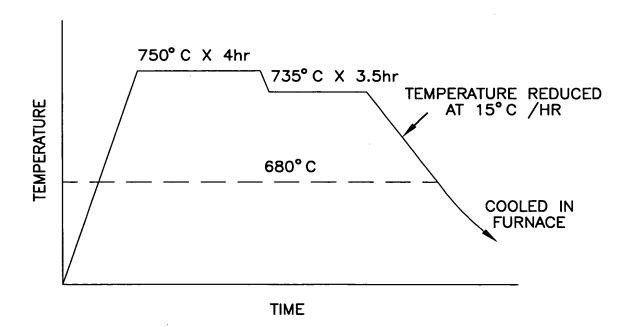


FIG.11B



Inventor: Ando, et al.

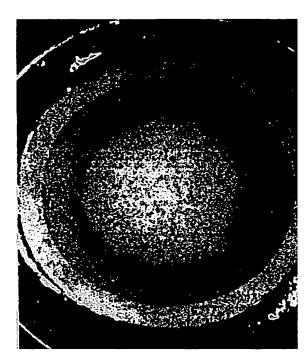
Docket No.: 12052.0033USD2

Title: BILLET FOR COLD FORGING, METHOD OF MANUFACTURING BILLET FOR COLD FORGING, METHOD OF CONTINUOUSLY COLD-FORGING BILLET, METHOD OF COLD-FORGING

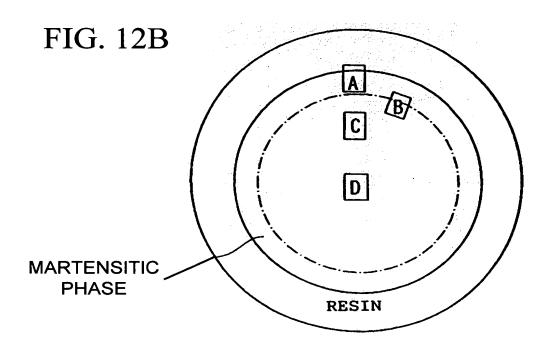
Serial No.: 10/789,347

Sheet 11 of 39

FIG. 12A



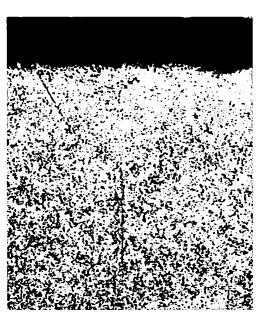
MARTENSITIC MATERIAL PRIOR TO SPHERODIZING ANNEALING X2. 1



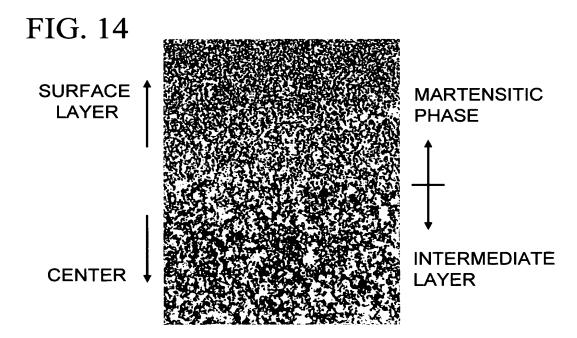
Inventor: Ando, et al. Docket No.: 12052.0033USD2

Title: BILLET FOR COLD FORGING, METHOD OF MANUFACTURING BILLET FOR COLD FORGING, METHOD OF CONTINUOUSLY COLD-FORGING BILLET, METHOD OF COLD-FORGING
Serial No.: 10/789,347
Sheet 12 of 39

FIG. 13



PRIOR TO SPHERODIZING ANNEALING **SURFACE LAYER X 100**



PRIOR TO SPHERODIZING ANNEALING SURFACE LAYER AND INTERMEDIATE LAYER X 200

Inventor: Ando, et al.
Docket No.: 12052.0033USD2
Title: BILLET FOR COLD FORGING, METHOD OF MANUFACTURING BILLET FOR
COLD FORGING, METHOD OF CONTINUOUSLY COLD-FORGING BILLET, METHOD
OF COLD-FORGING
Serial No.: 10/789,347
Sheet 13 of 39

FIG. 15



PRIOR TO SPHERODIZING ANNEALING 1/2 R PART X 400

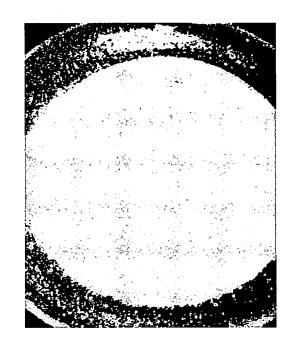
FIG. 16



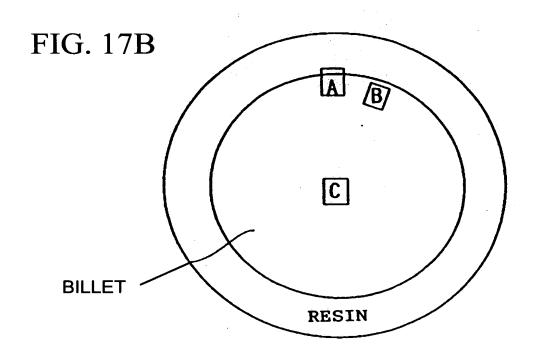
PRIOR TO SPHERODIZING ANNEALING CENTRAL PART X 400

Inventor: Ando, et al.
Docket No.: 12052.0033USD2
Title: BILLET FOR COLD FORGING, METHOD OF MANUFACTURING BILLET FOR
COLD FORGING, METHOD OF CONTINUOUSLY COLD-FORGING BILLET, METHOD
OF COLD-FORGING
Serial No.: 10/789,347
Sheet 14 of 39

FIG. 17A



MARTENSITIC MATERIAL
AFTER SPHERODIZING ANNEALING PATTERN 1
X2. 1



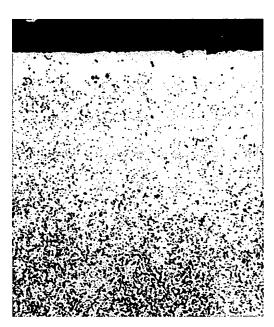
Inventor: Ando, et al. Docket No.: 12052.0033USD2

Title: BILLET FOR COLD FORGING, METHOD OF MANUFACTURING BILLET FOR COLD FORGING, METHOD OF CONTINUOUSLY COLD-FORGING BILLET, METHOD OF COLD-FORGING

Serial No.: 10/789,347

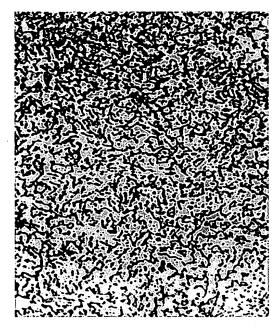
Sheet 15 of 39

FIG. 18



AFTER SPHERODIZING ANNEALING PATTERN 1 **SURFACE LAYER X 100**

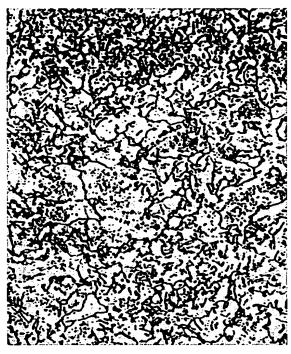
FIG. 19



AFTER SPHERODIZING ANNEALING PATTERN 1 **SURFACE LAYER X 400**

Inventor: Ando, et al.
Docket No.: 12052.0033USD2
Title: BILLET FOR COLD FORGING, METHOD OF MANUFACTURING BILLET FOR
COLD FORGING, METHOD OF CONTINUOUSLY COLD-FORGING BILLET, METHOD
OF COLD-FORGING
Serial No.: 10/789,347
Sheet 16 of 39

FIG. 20

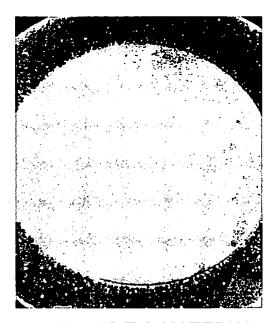


AFTER SPHERODIZING ANNEALING PATTERN 1 1/2 R PART X 400

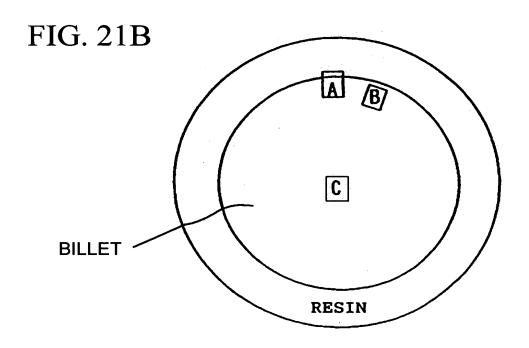
Inventor: Ando, et al.
Docket No.: 12052.0033USD2
Title: BILLET FOR COLD FORGING, METHOD OF MANUFACTURING BILLET FOR
COLD FORGING, METHOD OF CONTINUOUSLY COLD-FORGING BILLET, METHOD

OF COLD-FORGING Serial No.: 10/789,347 Sheet 17 of 39

FIG. 21A



MARTENSITIC MATERIAL AFTER SPHERODIZING ANNEALING PATTERN 1 X2. 1



Inventor: Ando, et al.
Docket No.: 12052.0033USD2
Title: BILLET FOR COLD FORGING, METHOD OF MANUFACTURING BILLET FOR
COLD FORGING, METHOD OF CONTINUOUSLY COLD-FORGING BILLET, METHOD
OF COLD-FORGING

Serial No.: 10/789,347 Sheet 18 of 39

FIG. 24

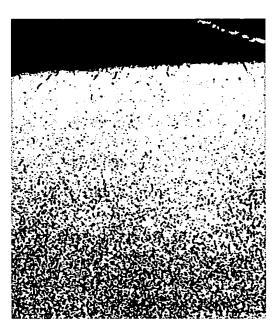


AFTER SPHERODIZING ANNEALING PATTERN 1 1/2 R PART X 400

Inventor: Ando, et al.
Docket No.: 12052.0033USD2
Title: BILLET FOR COLD FORGING, METHOD OF MANUFACTURING BILLET FOR COLD FORGING, METHOD OF CONTINUOUSLY COLD-FORGING BILLET, METHOD

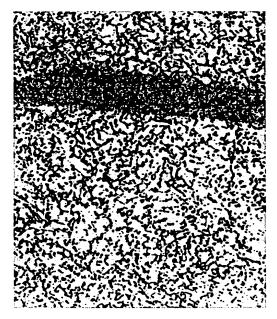
OF COLD-FORGING Serial No.: 10/789,347 Sheet 19 of 39

FIG. 22



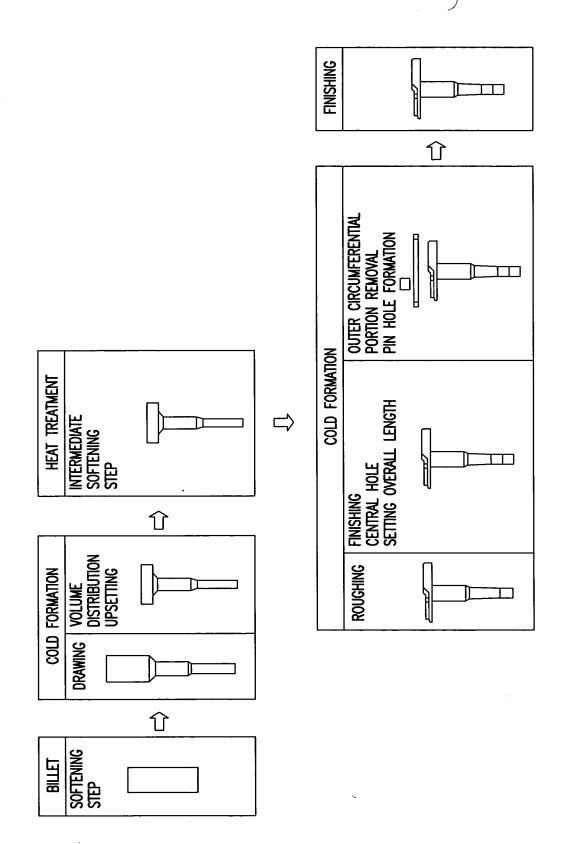
AFTER SPHERODIZING ANNEALING PATTERN 2 SURFACE LAYER X 100

FIG. 23



AFTER SPHERODIZING ANNEALING PATTERN 2 **SURFACE LAYER X 400**

Inventor: Ando, et al.
Docket No.: 12052.0033USD2
Title: BILLET FOR COLD FORGING, METHOD OF MANUFACTURING BILLET FOR
COLD FORGING, METHOD OF CONTINUOUSLY COLD-FORGING BILLET, METHOD
OF COLD-FORGING
Serial No.: 10/789,347
Sheet 20 of 39



Inventor: Ando, et al.
Docket No.: 12052.0033USD2
Title: BILLET FOR COLD FORGING, METHOD OF MANUFACTURING BILLET FOR
COLD FORGING, METHOD OF CONTINUOUSLY COLD-FORGING BILLET, METHOD
OF COLD-FORGING
Serial No.: 10/789,347
Sheet 21 of 39

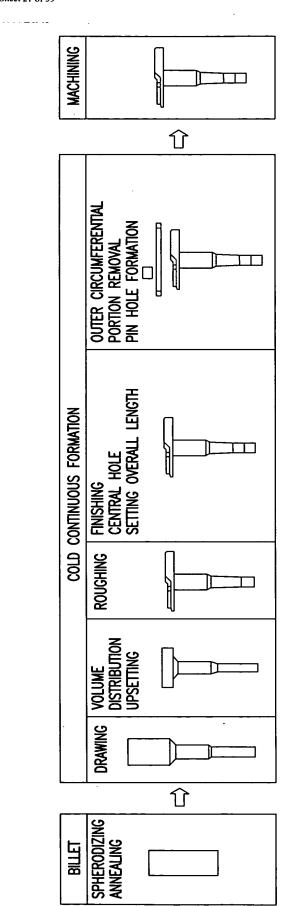


FIG.26

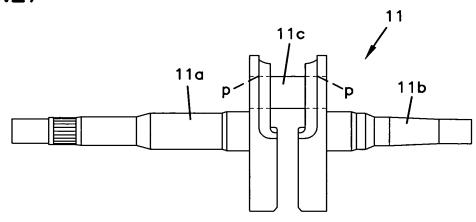
Inventor: Ando, et al.

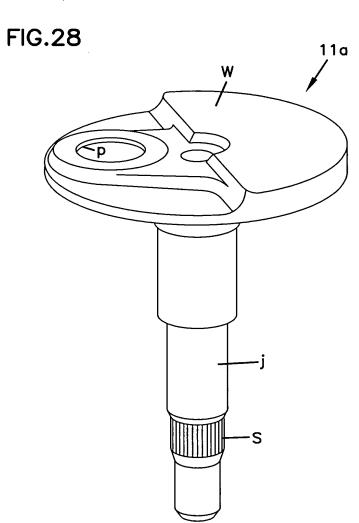
Docket No.: 12052.0033USD2

Title: BILLET FOR COLD FORGING, METHOD OF MANUFACTURING BILLET FOR COLD FORGING, METHOD OF CONTINUOUSLY COLD-FORGING BILLET, METHOD OF COLD-FORGING
Serial No.: 10/789,347

Sheet 22 of 39

FIG.27





Inventor: Ando, et al.

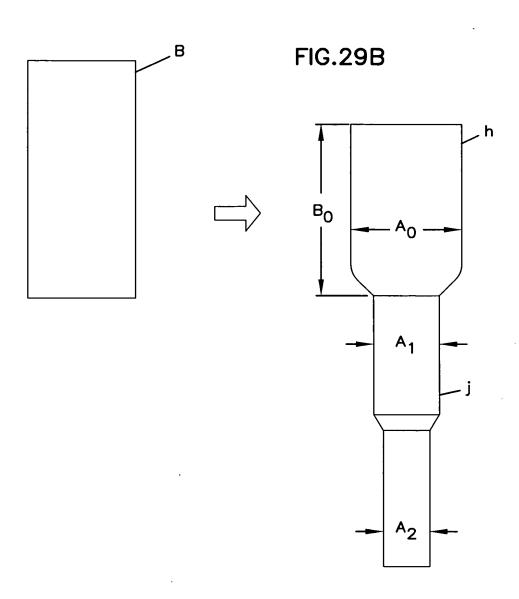
Docket No.: 12052.0033USD2

Title: BILLET FOR COLD FORGING, METHOD OF MANUFACTURING BILLET FOR COLD FORGING, METHOD OF CONTINUOUSLY COLD-FORGING BILLET, METHOD OF COLD-FORGING

Serial No.: 10/789,347

Sheet 23 of 39

FIG.29A



Inventor: Ando, et al.
Docket No.: 12052.0033USD2
Title: BILLET FOR COLD FORGING, METHOD OF MANUFACTURING BILLET FOR
COLD FORGING, METHOD OF CONTINUOUSLY COLD-FORGING BILLET, METHOD
OF COLD-FORGING
Serial No.: 10/789,347
Sheet 24 of 39

FIG.30A

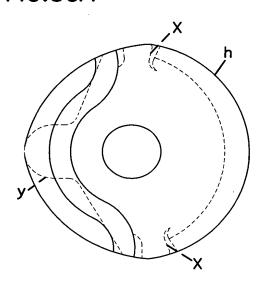


FIG.30B

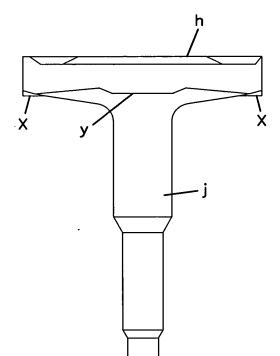
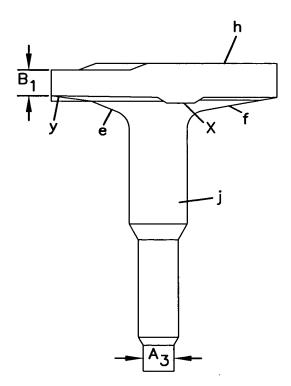


FIG.30C



Inventor: Ando, et al.
Docket No.: 12052.0033USD2
Title: BILLET FOR COLD FORGING, METHOD OF MANUFACTURING BILLET FOR COLD FORGING, METHOD OF CONTINUOUSLY COLD-FORGING BILLET, METHOD OF COLD-FORGING
Serial No.: 10/789,347
Sheet 25 of 39

FIG.31A

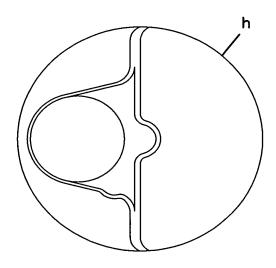
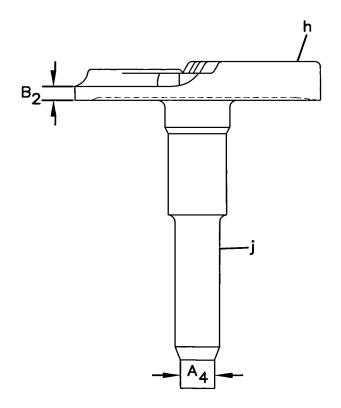


FIG.31B



Inventor: Ando, et al.
Docket No.: 12052.0033USD2
Title: BILLET FOR COLD FORGING, METHOD OF MANUFACTURING BILLET FOR
COLD FORGING, METHOD OF CONTINUOUSLY COLD-FORGING BILLET, METHOD
OF COLD-FORGING
Serial No.: 10/789,347
Sheet 26 of 39

FIG.32A

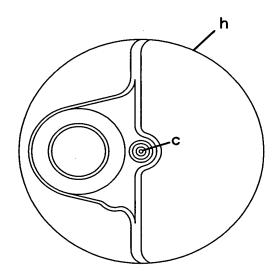
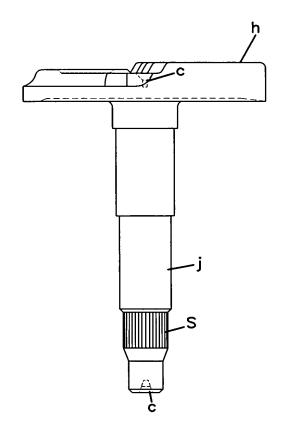


FIG.32B



Inventor: Ando, et al.
Docket No.: 12052.0033USD2
Title: BILLET FOR COLD FORGING, METHOD OF MANUFACTURING BILLET FOR
COLD FORGING, METHOD OF CONTINUOUSLY COLD-FORGING BILLET, METHOD
OF COLD-FORGING.
Serial No.: 10/789,347
Sheet 27 of 39

FIG.33A

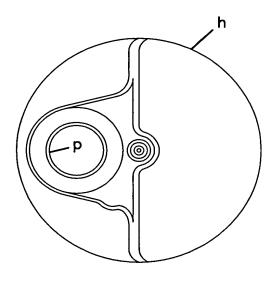
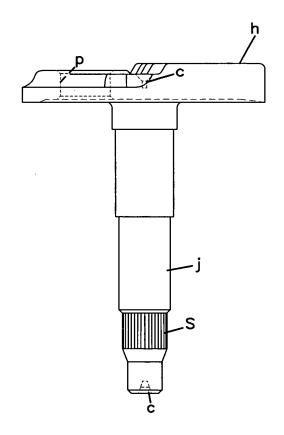


FIG.33B



Inventor: Ando, et al.
Docket No.: 12052.0033USD2
Title: BILLET FOR COLD FORGING, METHOD OF MANUFACTURING BILLET FOR
COLD FORGING, METHOD OF CONTINUOUSLY COLD-FORGING BILLET, METHOD
OF COLD-FORGING
Serial No.: 10/789,347
Sheet 28 of 39

FIG.34A



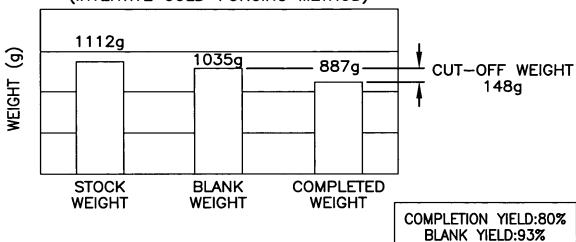
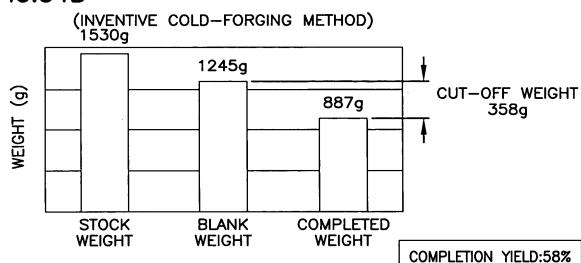
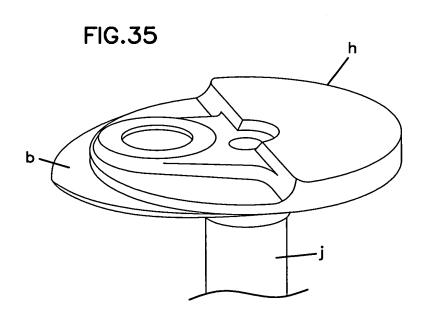


FIG.34B



BLANK YIELD:81%



Inventor: Ando, et al.

Docket No.: 12052.0033USD2

Title: BILLET FOR COLD FORGING, METHOD OF MANUFACTURING BILLET FOR COLD FORGING, METHOD OF CONTINUOUSLY COLD-FORGING BILLET, METHOD

Inventor: Ando, et al.

Docket No.: 12052.0033USD2

Title: BILLET FOR COLD FORGING, METHOD OF MANUFACTURING BILLET FOR COLD FORGING, METHOD OF CONTINUOUSLY COLD-FORGING BILLET, METHOD

OF COLD-FORGING Serial No.: 10/789,347 Sheet 30 of 39

FIG.37A

SLIP TORQUE

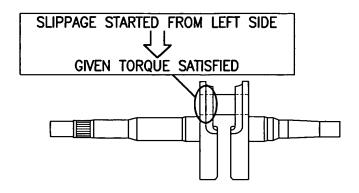


FIG.37B

- N CURVE (ROTATIONAL BENDING FATIGUE TEST)

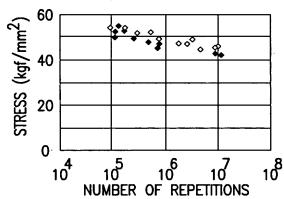
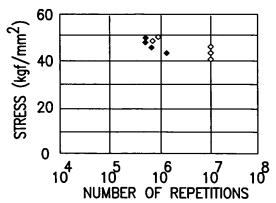


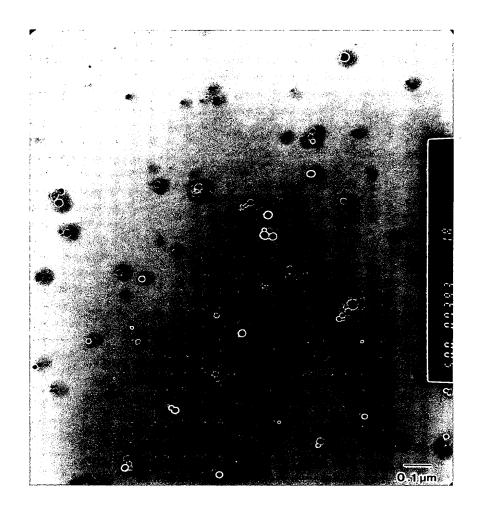
FIG.37C

S - N CURVE (SOLID BENDING FATIGUE TEST)



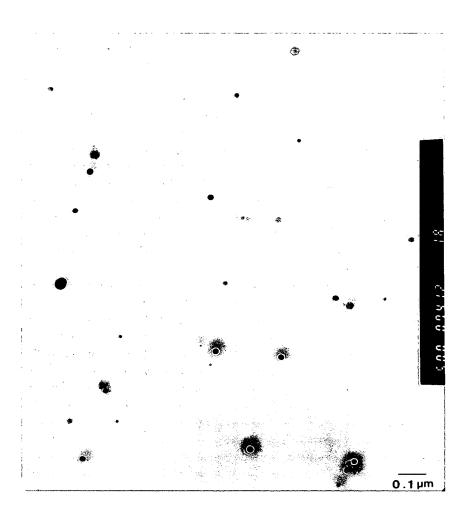
Inventor: Ando, et al.
Docket No.: 12052.0033USD2
Title: BILLET FOR COLD FORGING, METHOD OF MANUFACTURING BILLET FOR
COLD FORGING, METHOD OF CONTINUOUSLY COLD-FORGING BILLET, METHOD
OF COLD-FORGING
Serial No.: 10/789,347
Sheet 31 of 39

FIG. 39



Inventor: Ando, et al.
Docket No.: 12052.0033USD2
Title: BILLET FOR COLD FORGING, METHOD OF MANUFACTURING BILLET FOR COLD FORGING, METHOD OF CONTINUOUSLY COLD-FORGING BILLET, METHOD OF COLD-FORGING
Serial No.: 10/789,347
Sheet 32 of 39

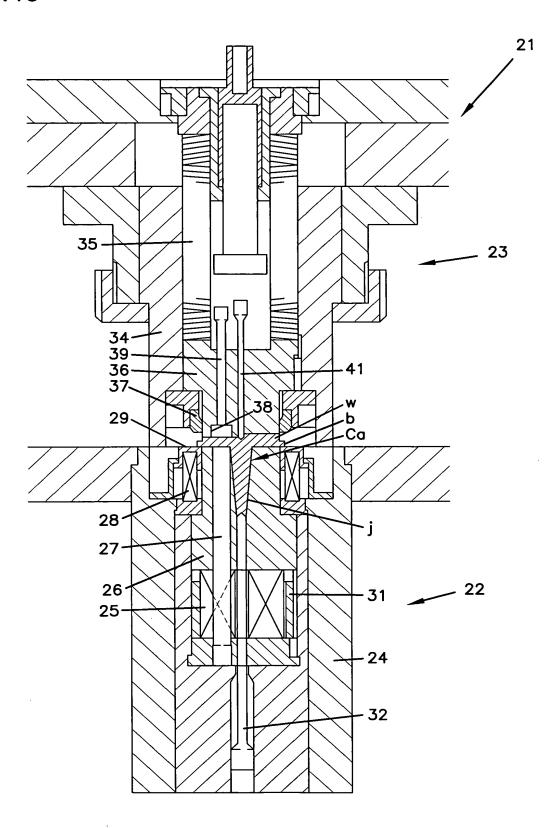
FIG. 38



Inventor: Ando, et al.
Docket No.: 12052.0033USD2
Title: BILLET FOR COLD FORGING, METHOD OF MANUFACTURING BILLET FOR
COLD FORGING, METHOD OF CONTINUOUSLY COLD-FORGING BILLET, METHOD

OF COLD-FORGING Serial No.: 10/789,347 Sheet 33 of 39

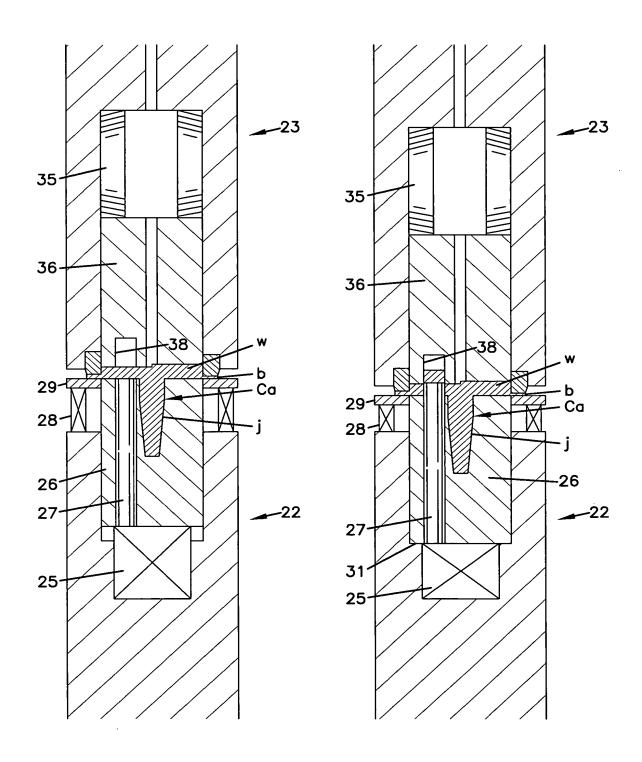
FIG.40



Inventor: Ando, et al.
Docket No.: 12052.0033USD2
Title: BILLET FOR COLD FORGING, METHOD OF MANUFACTURING BILLET FOR
COLD FORGING, METHOD OF CONTINUOUSLY COLD-FORGING BILLET, METHOD
OF COLD-FORGING
Serial No.: 10/789,347
Sheet 34 of 39

FIG.41A

FIG.41B



Inventor: Ando, et al.

Docket No.: 12052.0033USD2

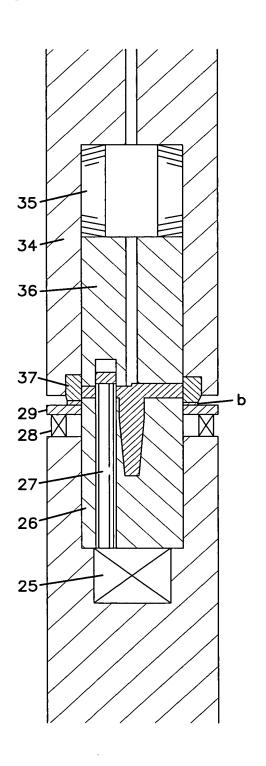
Title: BILLET FOR COLD FORGING, METHOD OF MANUFACTURING BILLET FOR COLD FORGING, METHOD OF CONTINUOUSLY COLD-FORGING BILLET, METHOD OF COLD-FORGING

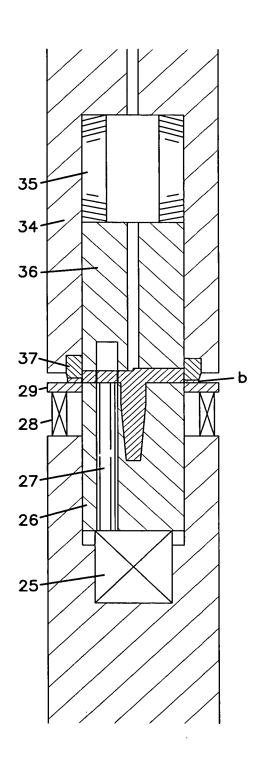
Serial No.: 10/789,347

Sheet 35 of 39

FIG.42A

FIG.42B





Inventor: Ando, et al.

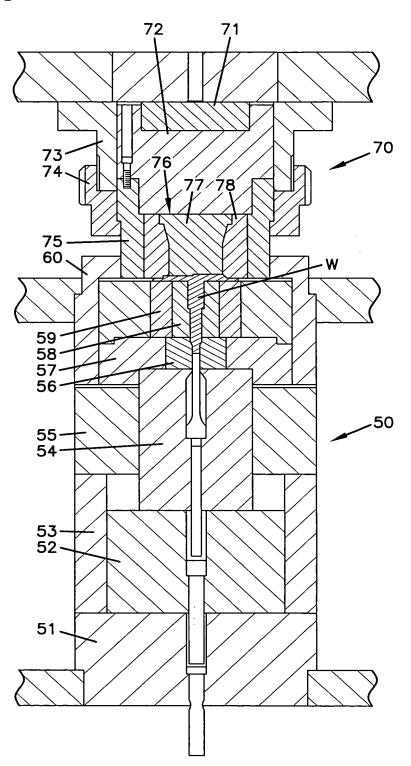
Docket No.: 12052.0033USD2

Title: BILLET FOR COLD FORGING, METHOD OF MANUFACTURING BILLET FOR COLD FORGING, METHOD OF CONTINUOUSLY COLD-FORGING BILLET, METHOD OF COLD-FORGING

Serial No.: 10/789,347

Sheet 36 of 39

FIG.43



Inventor: Ando, et al.
Docket No.: 12052.0033USD2
Title: BILLET FOR COLD FORGING, METHOD OF MANUFACTURING BILLET FOR COLD FORGING, METHOD OF CONTINUOUSLY COLD-FORGING BILLET, METHOD OF COLD-FORGING BILLET, METHOD Serial No.: 10/789,347
Sheet 37 of 39

FIG.44

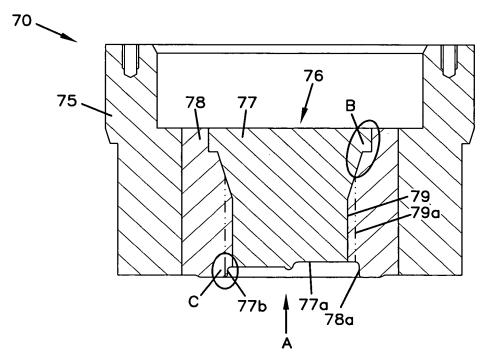
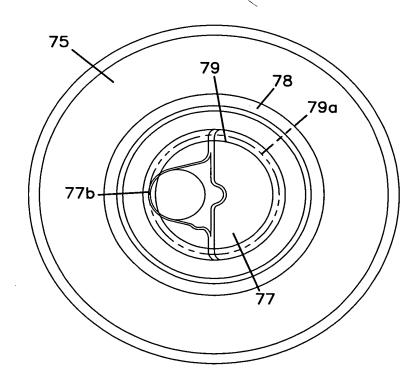
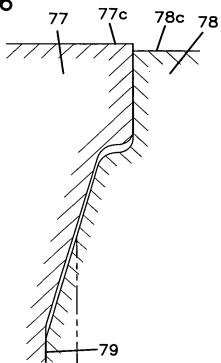


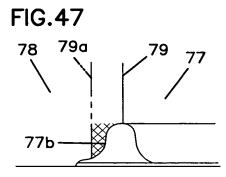
FIG.45

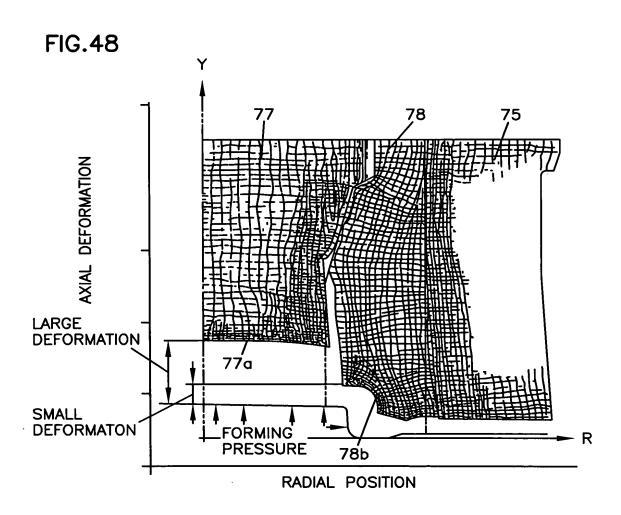


Inventor: Ando, et al.
Docket No.: 12052.0033USD2
Title: BILLET FOR COLD FORGING, METHOD OF MANUFACTURING BILLET FOR
COLD FORGING, METHOD OF CONTINUOUSLY COLD-FORGING BILLET, METHOD
OF COLD-FORGING
Serial No.: 10/789,347
Sheet 38 of 39









Inventor: Ando, et al.

Docket No.: 12052.0033USD2

Title: BILLET FOR COLD FORGING, METHOD OF MANUFACTURING BILLET FOR COLD FORGING, METHOD OF CONTINUOUSLY COLD-FORGING BILLET, METHOD OF COLD-FORGING

Serial No.: 10/789,347

Sheet 39 of 39

		BILLE	T MANU	BILLET MANUFACTURING PROCESS		ACDECT DATIO	CBACK
	SPHERODIZING ANNEALING PRIO DRAWING TO DRAWING	DRAWING	CUTTING	SPHERODIZING ANNEALING SUBSEQUENT TO DRAWING	SHOT BONDERIZING		PER
MATERIAL 1	NONE	NONE	0	0	0	506	35%
MATERIAL 2	NONE	(20%) O	0	0	0	347	2%
MATERIAL 3	0	(20%) O	0	0	0	300	%0

